A Seminal Case Study on Application of Last Planner System with Cash Flow Data for Improvement in Construction Management Practices

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Abstract

A major challenge faced by project managers is balancing the variables of scope, cost, and schedule. Changes in scope usually result in cost/schedule overruns.Variance in either or both of them creates disorder (typically increases it) in the estimated or projected time and cost. Therefore, controlling cost and schedule are two of the most critical aspects of a construction project. This research uses two already existing management theories, specifically Management by Means (MBM) and Management by Results (MBR), and analyzes a case where these two theories are combined with the goal of improving construction practices.

This research compares an eight month schedule in a construction project and relates Percentage of Planned activities Completed (PPC) with projected and actual draw (cash) calls. The research analyzes the question of how lean construction PPC captures variance in cost. The research method is based on a literature review, data collection, case study and data interpretation to answer the hypothesis that improvement in PPC over a particular month has a positive correlation with difference between cash calls. Because this research is limited to a time frame of 8 months in a single project, it is not statistically significant. However, this research serves to create a model template or pilot study for a larger study.

Keywords

Last Planner System; Cash Flow; Construction Management

Introduction

Construction is an extremely complicated field with a high degree of unpredictability in every task, time and condition (Allen and Iano 2004) when compared to other industries. Thus, the coordination and supervision of the construction process from inception to completion, while making certain that the project is completed on schedule and within budget, is both a science and an art. According to Warburtan (2011), any project consists of major constraints based on its scope, cost, and schedule. Coordinating these constraints is the major challenge faced by construction managers.

Construction managers tend to determine the best way to execute the task of coordination and supervision with the most cost-effective plan and schedule. This is typically done in a command and control top-down setting also called a "push schedule" (Xiong and Nyberg 2000). Another theory, chaos theory, indicates that minor changes in the project frequently have major schedule and cost implications and activating any corrective adjustment late into the project is often ineffective and expensive (Sterman 1992). In addition, the later the remedial action, the less is the ability to influence the project outcomes (Nepal et al. 2006). Along with the traditional goals of schedule and budget, factors like client satisfaction and total quality delivery of product and services make any project successful or unsuccessful.

This research focuses on established categorization of two different management theories, namely Management by Results (MBR) and Management by Means (MBM). The research employs a case study where these two theories can be combined for improved construction practices (see Fig. 1).

Management by Results (MBR), as the name itself suggests, is a target oriented management principle. In MBR, all processes, products and services contribute to the accomplishment of desired goals. Management, or the organization focuses primarily on financial

outcomes and their relationship with the schedule. Management by Means (MBM), on the other hand, is a new philosophy that focuses on resources, rather than finances, to achieve long term success through improvement in process, methods, approaches and their interrelations. These two generalized terms incorporate two principles of Earned Value Management (EVM) and Last Planner System (LPS) (Johnson and Broms 2000), respectively. According to Johnson (2006), the MBR progress curve is saw-toothed with intermittent low and high growth; whereas, MBM is a stepped progress, with gradual ascent to a desired goal (see Fig. 2).

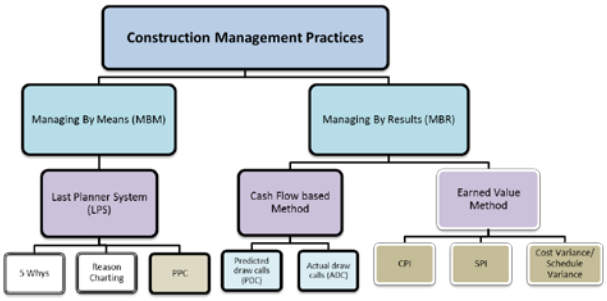

FIG. 1 COMPARISON OF MANAGEMENT BY MEANS AND MANAGEMENT BY RESULTS, WITH EXAMPLE ACTIVITIES USED IN EACH METHOD

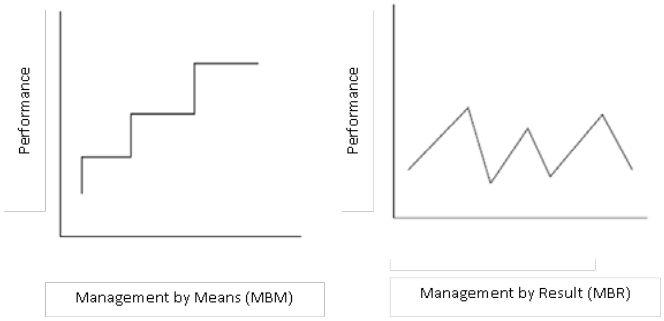

FIG. 2 MBM AND MBR PROGRESS CURVE (ADAPTED FROM JOHNSON 2006)

Research Method

The research method revolves around the hypothesis that improvements in PPC also improve the budget of the project. In this research, two different management theories are examined through a case study, where the theories are combined for improved construction practices. The research design compiles a literature review (for establishing background on related studies), data collection (present scenario), case study, and data interpretation (establishing the hypothesis) as sources to provide a graphical and coherent outcome. The research paper is confined to a single case study with a time frame of 8 months.

The research method is comprised of three steps that lead to better understanding and consequences of applying MBM and MBR theories together in a project. The research design goes through four phases before data interpretation and reaching conclusions:

a. Preliminary design

b. Identification based design

c. Analysis design

d. Interpretation and validation

The data interpretation is done with the help of statistical analysis. This statistical analysis will aid in establishing and validating the hypothesis.

Although the literature shows significant evidence that some managers implement a micro-MBR management tool by assigning and tracking costs on each weekly assignment with Last Planner System, it is rare to find a project that uses both systems simultaneously (Kim & Ballard 2010). Since there are very few construction projects that use both LPS and EVM, an alternative that uses monthly schedule of payments as a source of financial data was coined. The case study is based on the Northside Residence Hall at Texas A&M University (TAMU). This project is a GMP contract; all the schedules and scopes are dependent on the original GMP amount. Thus, the type of contract makes this practice comparable to using MBR.

Preliminary design concentrates on finding various avenues in which a thesis can be created that relates to lean construction principles and construction management principles. A relevant and presumed topic was then established. Prospective and relevant data was listed and compiled in order to complete the research work. Identification of data and research method was considered the most critical step in the research and was performed with utmost attention.

This design consists of two models:

- Data collection and analysis
- Data interpretation

The data collection and data analysis phase started with data collection from the Northside Residence Hall project; it incorporated analyzing the PPC for each week, and analyzing the predicted and actual draw calls (see Fig.3).

The data was collected in two ways: Percent Planned Complete (PPC) and Projected and Actual Draw Calls (PDC and ADC).

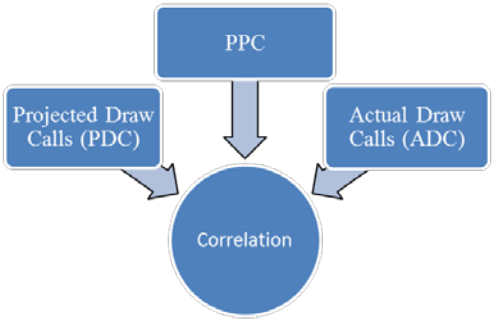

FIG. 3 DATA COLLECTIO MODEL

PPC: A tabular format was provided that showed number of activities planned and number of activities completed as planned. Calculations for PPC were also done and an average PPC for each month was calculated for further data comparisons.

ADC and PDC: Data was compiled as schedule of payment for each month comprised of original Guaranteed Maximum Price (GMP) amount ADC, PDC, cumulative amounts for each month and graphical representation of ADC and PDC.

Once the data was compiled, required comparative variables were formulated . These formulated variables account for the source of multivariate analysis, while considering the results of all variables on the responses of interest. These variables include:

- Average monthly PPC (P_i)
- PDC-ADC

Research focused on comparing variables that related to the PPC data. Using only PPC and the ADC or PDC directly showed no strong correlation. Therefore, these collected data were transformed into various combinations of data derivatives and then they were analyzed through Pearson's correlation coefficient.

Once the calculations and graphics were finished, interpretation became more comprehensible and succinct. Based on these data and inferences, a correlation analysis method was chosen to validate the hypothesis.

Relevant outputs like correlation coefficient and probabilities are typically obtained in order to get statistically significant outcomes. Although this study is based on a single case study and statistically significant data cannot be obtained, it can offer foundation to future studies.

Data was obtained in the form of PPC, ADC and PDC. Appropriate data was assembled and pertinent variables were worked out from the original given variables. A primary test was run using all the variables and their interrelations. This test indicated a relationship between all of the variables, but their correlation and p-values were not determined. Later, a similar test was done using significant variables in a Pearson's correlation analysis.

Data Analysis

This research uses data from the $43 million, 600-bed project built by Linbeck LLC. Three types of data were collected from Linbeck LLC and the Northside Residence Hall project. These data are:

- Percent Planned Complete (PPC) (see Table 1)
- Projected Monthly Billing
- Actual monthly billing

TABLE 1 REAL PROJECT PPC DATA

NORTHSIDE RESIDENCE HALL PPC DATA					
No.	**Week**	**No. of planned activities**	**No. of completed tasks**	**PPC**	**Average PPC per month**
1	6/6/11	10	9	90%	86%
2	6/13/11	12	10	83%	
3	6/20/11	22	19	86%	
4	6/27/11	29	25	86%	
5	7/4/11	35	31	89%	90%
6	7/11/11	25	24	96%	
7	7/18/11	27	26	96%	
8	7/25/11	25	20	80%	
9	8/1/11	26	20	77%	85%
10	8/8/11	22	18	82%	
11	8/15/11	15	10	67%	
12	8/22/11	10	10	100%	
13	8/29/11	5	5	100%	
14	9/5/11	8	7	88%	83%
15	9/12/11	3	3	100%	
16	9/19/11	4	2	50%	
17	9/26/11	15	14	93%	
18	10/3/11	18	14	78%	80%
19	10/10/11	16	10	63%	
20	10/17/11	15	14	93%	
21	10/24/11	19	16	84%	
22	10/31/11	26	22	85%	
23	11/7/11	35	29	83%	84%
24	11/14/11	28	24	85%	
25	11/21/11	19	17	89%	
26	11/28/11	32	25	78%	
27	12/5/11	26	20	77%	83%
28	12/12/11	32	25	78%	
29	12/19/11	19	18	95%	
30	12/26/11	22	18	82%	
31	1/2/12	28	22	79%	84%
32	1/9/12	33	30	91%	
33	1/16/12	35	32	91%	
34	1/23/12	45	34	76%	
	totals	**741**	**623**		**84.4%**

These data were created in Linbeck templates with the help of project managers during their daily and weekly meetings. Research focused on comparing variables related to the PPC data.

Once the data was compiled, required comparative variables were formulated (see Table 2). These formulated variables account for the source of multivariate analysis, while considering the results of all variables on the responses of interest. These variables include:

- Average monthly PPC (P_i): It was difficult to relate or compare weekly PPC with monthly cash flow. Hence, average monthly PPC was calculated to relate it with ADC and PDC. P represents PPC while, $_{(i)}$ represents month, with i=1 as June.
- PDC-ADC: This difference was calculated in order to see whether actual draw calls were greater than the projected. Therefore, If PDC-ADC is negative, it shows actual expenses were more than projected. If PDC-ADC is positive, it shows actual expenses were less than predicted.
- Increase or Decrease in PPC ($P_{(i)} - P_{(i-1)}$): This was calculated by subtracting PPC for 1 month from that of previous month, where, $_{i-1}$ is preceding month. If the difference is positive, there is improvement. If the difference is negative there is worsening in performance. Average PPC – PPC for first week of month ($P_{(i)} - P_{(i1)}$): This calculation shows whether there was improvement in PPC over the course of a month. The formula shows $P_{(i)}$ as average PPC of a month, whereas, $P_{(i1)}$ shows PPC for the first week of the month. Therefore, if this difference is positive, it means there is improvement and if it is negative, there is declination.
- Percentage change in draw calls ((-(PDC-ADC)/PDC)*100: The variable represents whether there was increase or decrease in expense from the PDC amount. If the value is positive, expenses are more than projected and if it is negative, fewer expenses exist than were projected.

In this research, analysis and observation of multiple variables was needed as a part of the data interpretation. These observations included finding the strength of the relationship between two variables. Therefore, a correlation was developed between the variables (Pi) and PDC ($), (Pi) and ADC, (Pi) and PDC-ADC ($), PDC-ADC ($) and P (i) - P (i1) . After computing these variables, we composed them in tabular form and their correlations were determined through Pearson's correlation analysis. Pearson's correlation coefficient is usually denoted by ρ (rho). It signifies statistical dependence between two variables. When one variable is a perfect function of the other, a perfect Spearman correlation of +1 or -1 occurs.

TABLE 2 VARIABLES FOR THE MULTIVARIATE DATA ANALYSIS

Month	(Pi) %	PDC ($K)	ADC ($K)	Δ ($K)	P(i) - P(i-1) %	(-(Δ) /PDC)* 100	P (i) - P(i1) %
June	0.86	602.2	804.7	(202.5)	0	33.63	-3.53
July	0.90	993.9	885.7	108.2	0.04	-10.88	1.65
Auguts	0.85	1,371.1	0	1,371.1	-0.05	--	8.16
Sept.	0.83	1,728.3	2,016.1	(287.8)	-0.02	16.66	-4.79
Oct.	0.80	2,060.3	1,985.9	74.4	-0.02	-3.61	2.71
Nov.	0.84	2,362.3	2,265.9	96.4	0.04	-4.08	1.19
Dec.	0.83	2,629.8	--	--	-0.01	--	5.98
Jan.	0.84	2,858.9	--	--	0.01	--	5.54

Pearson's correlation coefficient shows that the variables PDC-ADC and P (i) - P (i1) have a strong positive correlation of 0.8286. Although the correlations between variables like ADC and PDC increase/decrease vs. average first week, the relationships in PDC- ADC, PDC and ADC, average PPC vs. ADC and PDC are strong, but the effects are not significant. The reason for this is they all are derived from the same or similar variable. Thus, their strong correlation does not insinuate any valid conclusion.

The scatter plot matrix suggests that for every negative value of PDC-ADC, there is a corresponding negative value for $P_{(i)} - P_{(i1)}$. Hence, they are positively correlated (Fig. 4) with a correlation coefficient of 0.8286. Therefore, whenever there is decrease in reliability over the consecutive weeks of a month, there is an increase in ADC as compared to the projected value. This means the owner must pay more than expected.

The scatter plot matrix represents the distribution of both variables. The cross matrix shows correlation between ($P_{(I)} - P_{(I1)}$) and PDC- ADC. Fig 6 shows the relation between the two variables with reference to the quadrants. For example, quadrant I depicts both variables as positive. Thus, each increase in reliability for a month corresponds with decrease in monthly expenses for the subsequent month. From the p-value calculated in Spearman's test of 0.0416; we can be 95%

confident that the null hypothesis is rejected. There is significant evidence that the two variables are related to one another. Since the sample size is too small to conclude and establish statistically significant data, these outcomes can be considered for a future study that incorporates significant sample size.

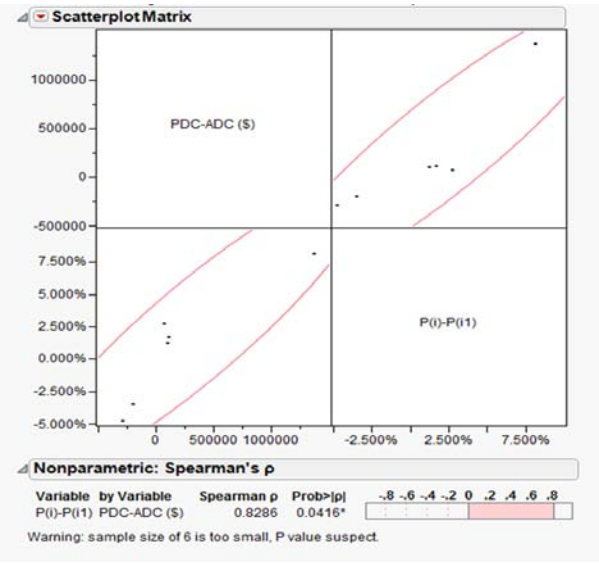

FIGURE 4 SCATTER PLOT MATRIX SHOWING MATHEMATICAL CORRELATION BETWEEN PDC-ADC AND P (I) - P (I1)

CONCLUSION

The data analysis shows there is a positive correlation of 0.8286 between PDC-ADC and P (i) – P (i1). The outcomes suggest that when there was an improvement in PPC throughout the month from the PPC of the first week, the ADC was less than or equal to PDC. This shows that even a slight improvement over the month or in consecutive months can result in a less expensive project. The p-value (0.0416) calculated in the Pearson's test rejects the null hypothesis by 95% confidence.

This pilot study explored various avenues related to management principles and their applications. The primary goal of the research was to track the relation between cash flow and LPS and how PPC reflects variations in cash flow or vice versa. From the data analysis, the null hypothesis was rejected and hence, it gives suggestive implications on using a similar type of data for detailed research on a similar path. Following are a few surmised contributions to industry and research:

- Suggests opportunity for future studies along the same direction with a more detailed study in order to achieve statistical significance.
- Correlations between certain variables acting in a construction project.

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